Innovative Distributed Power Interconnection and Control Systems

Bill Liss
Gas Technology Institute, Des Plaines, IL
Greg Miller
Encorp, Windsor, CO

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Presentation Overview

- **Market-Driven, Technology-Based Solutions**
  - **Collaborative NREL/DOE program and goals**
- **Distributed Power Market**
  - **System applications & customer needs**
  - **Case Study: Chowchilla II Power Generation Station**
- **Accomplishments and Summary**

Development of Innovative Distributed Power Interconnection and Control Systems
Subcontract No. 30605-04
Awarded Under the NREL/DOE Distributed Power Program
Distributed Power System Integration Research and Development
NREL Technical Monitor: Tom Basso
Principal Investigator: Bill Liss, Gas Technology Institute, Des Plaines, IL
Subtier Principal Investigators: Larry Adams and Randy West, Encorp, Windsor, CO

NREL/DOE Project Objective and Goals

Program Objective

Key enabling technologies and system-level integration to help Distributed Power market participants more fully capture the total value provided by DP products.

- **Cost-effective DP grid interconnection products, software, and communication solutions**
- **Improved economics for broad range of DP power systems**
- **Enhanced DP product capability to integrate, interact, and provide operational benefits**
  - **Within building energy management systems and electric power systems**
  - **Resource planning, ancillary services, and load/demand management**

NREL/DOE Advanced Interconnect System:
Three Phase Work Plan

- **Base Year:**
  - Core Technology & Software Development
  - Develop Next Generation *en*power™ Controller
  - Significant Performance Enhancement
  - Further Switchgear Packaging Improvement
- **Option Year 1:**
  - Application & System Level Command and Control
- **Option Year 2:**
  - Further Development/Demonstration of System Benefits and Validation of Industry Communication Standards
- **Program includes substantial cost-sharing by GTI/Encorp**
  - Over 5:1 during the Base Year

Program Plan/Tasks

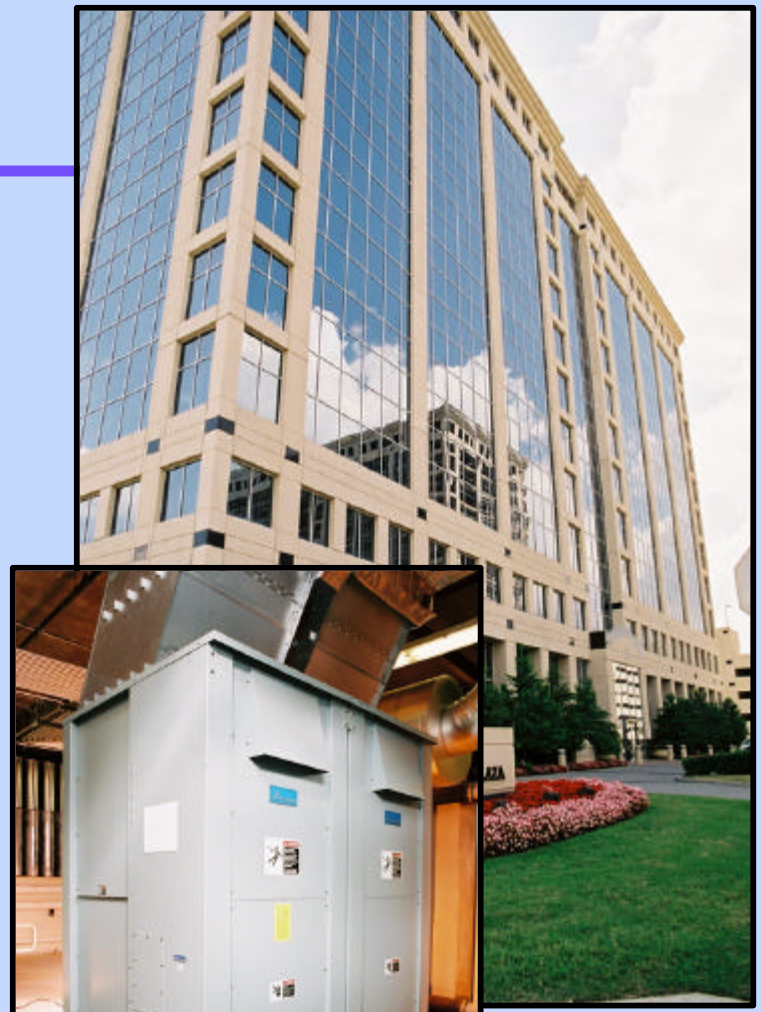
	Core Enabling Technology	
Year One	**(1)**	**Develop Prototype Advanced Controller**
	(2)	**Develop Prototype Power Sensing Board**
	(3)	**Expanded Suite of Communication Capabilities**
	(4)	**Interface for Revenue-Grade Meter**
	(5)	**Demonstrate Interconnect DP Device**
	System Level Command & Control	
Year Two	**(6)**	**Type Testing**
	(7)	**System Command and Control**
	(8)	**Demonstration of Controlled DP**
	Interoperability & Communications	
Year Three	**(9)**	**Interoperability Systems Analysis**
	(10)	**Demonstration of Grid-DP Interoperability**

Program Team

- **Gas Technology Institute - GTI/GRI**
  - **Bill Liss**
  - **Karen DePodesta**
- **Encorp**
  - **Randy West, Program Manager**
  - **Larry Adams, Chief Engineer**
  - **Greg Miller, Vice President**

Who Is Encorp?

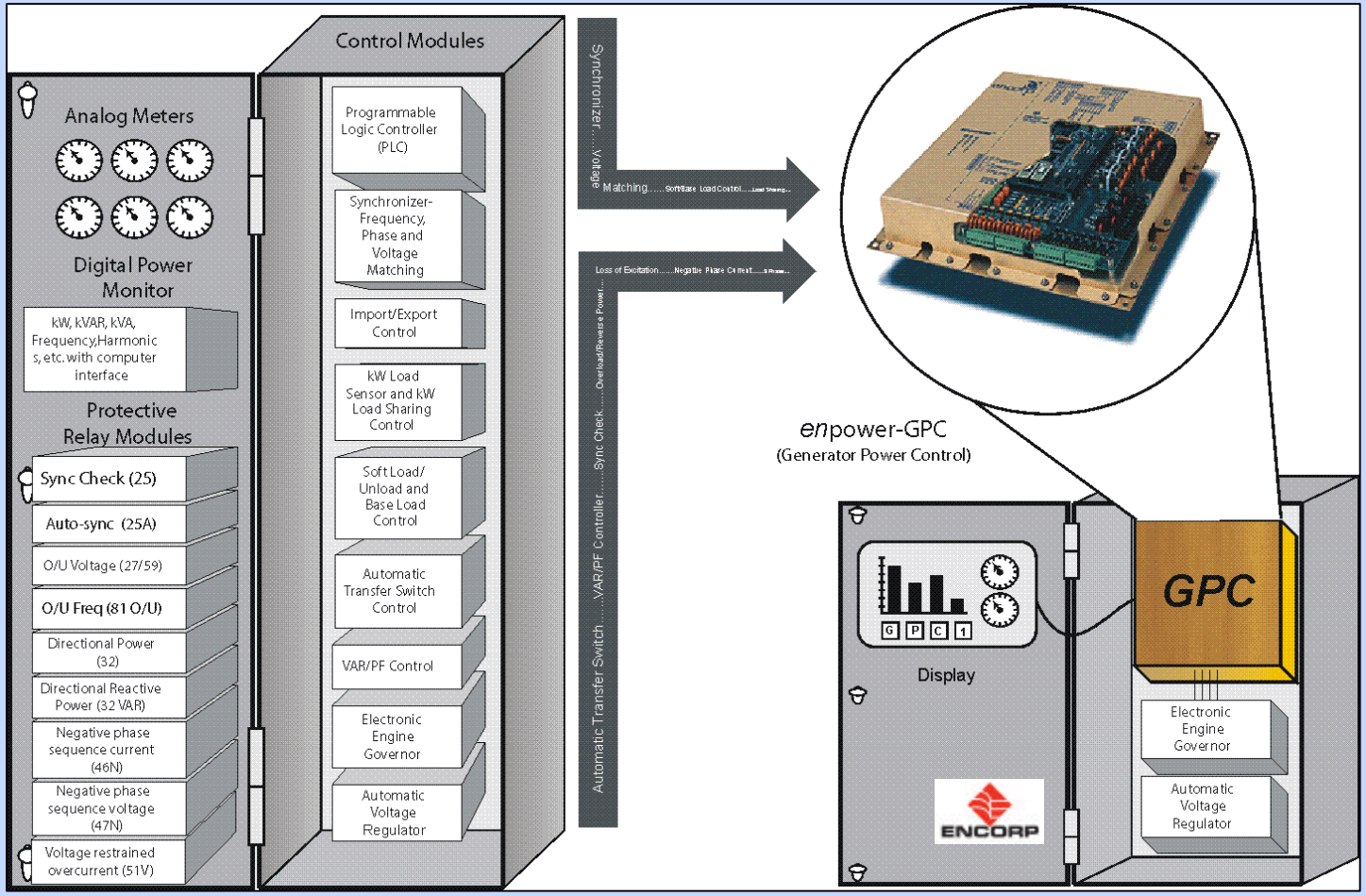
- Fast-growing, technology-driven company located in Windsor, CO
- Design, develop, and make communication, control, and grid interconnection products
  - Services for the global power markets
  - Focused on power quality, reliability, distributed power
- Extensive market experience:
  - Over 1700 different applications
  - Over 1,000 MW installed capacity



Encorp's Differentiator:
The Gold Box & Remote Energy Automation

Traditional Method

Encorp's Digital Solution

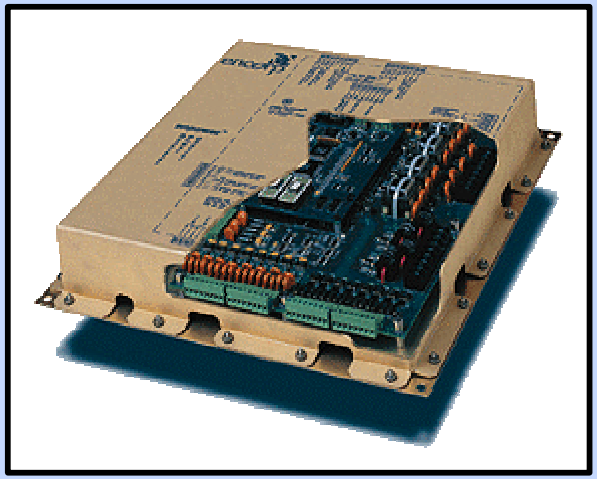


Core Enabling Technology
GPC Enhancements During Base Year

- Performance
- Communications
- Scalability
- IEEE P1547 Compliant
- Functionality
- Programmability
- Serviceability
- Lower System Cost

Inside the Gold Box

- Digital Control Features
- Prime Mover Start/Stop Sequencing
- Prime Mover Monitoring
- Generator Control Functions
- Utility and Generator Protective relays
- Power Metering (Energy)
- Power Quality Monitoring (Harmonics)
- PLC Logic and Network communications for I/O expandability
- Local & remote PC communications interface



Digital Switchgear

Traditional Method

The ENCORP Solution

Simple Design
Cleaner Door Panels
Less Components
High Reliability
Easier to Manufacture

Encorp's End to End Energy Solutions

entelligent
Virtual Power Plant
Software & Comm.

MMC & GPC Controls

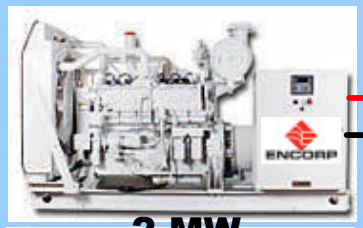
Digital Switchgear
100 – 600 Amps

Digital Switchgear
800 – 5000 Amps

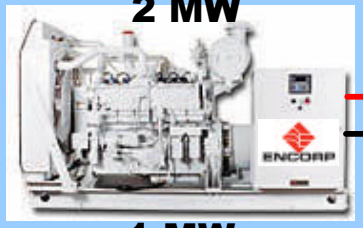
Inside Panel

Outside Panel

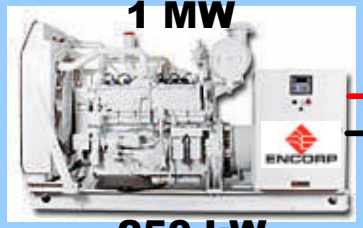
Encorp's End to End Energy Solutions



2 MW



1 MW



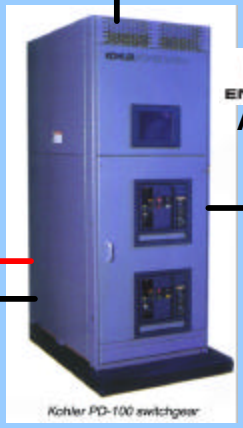
250 kW

100 kW

Encorp Gateway

*ent*elligent-VPP
Virtual Power Plant

Building Load



ENCORP
ATS

Distribution
Substation

Transmission
Line

Utility or IPP

Power Network
LonWorks Network

Market Needs

- **Technology Driven By Customer Needs**
  - **Cost savings**
  - **Reliability**
  - **Good power quality**
  - **Interconnect security & safety**
  - **Ease of system integration**
  - **Ease of use**
  - **Access to data & knowledge**
  - **Flexibility**

- **Application Flexibility**
  - **Customer/Utility-Owned DG**
    - Interruptible rate programs, relieving utility constraints
  - **Retail-Type DG**
    - Campus power, inside utility meter
  - **Critical Power Systems**
    - Institutional, financial, e-commerce, industrial
  - **CHP/Cogeneration**
  - **Wholesale-Type DG**
    - Wholesale energy/capacity trading, Distribution grid peaking

…control and software solutions that are flexible and can simplify complicated system problems

Case Study

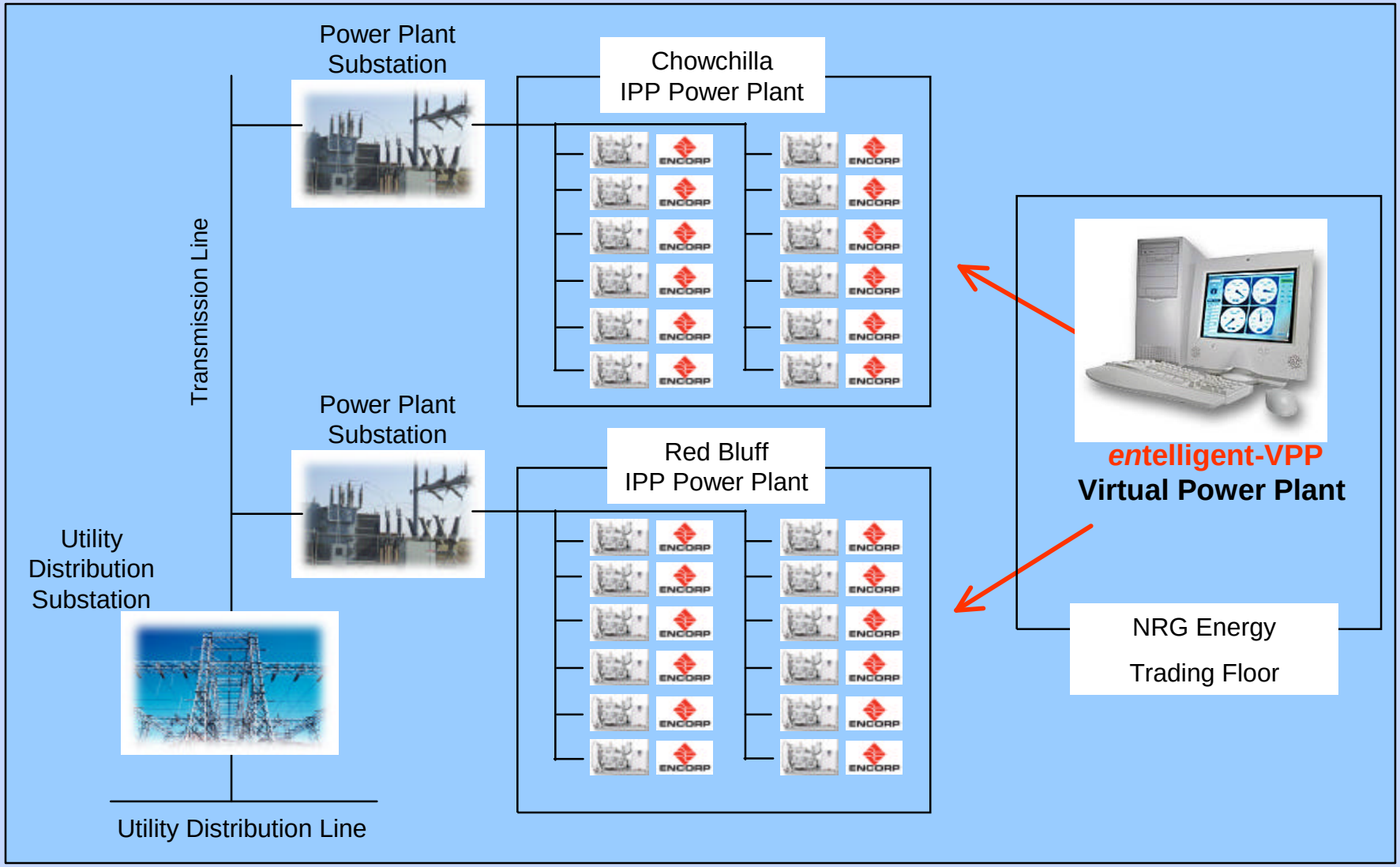
- **Field Testing Case Study – Chowchilla II (California)**
  - **Wholesale-type DG Application**
    - California ISO
  - **Application of GPC controller and related Encorp products**
    - 16 natural gas fired Deutz generator sets (25 MW)
    - Owned & Operated by NRG Energy/NEO
      - Run from remote site (Minneapolis)
    - Operated in parallel with utility (PG&E)

Chowchilla 50 MW Power Plant

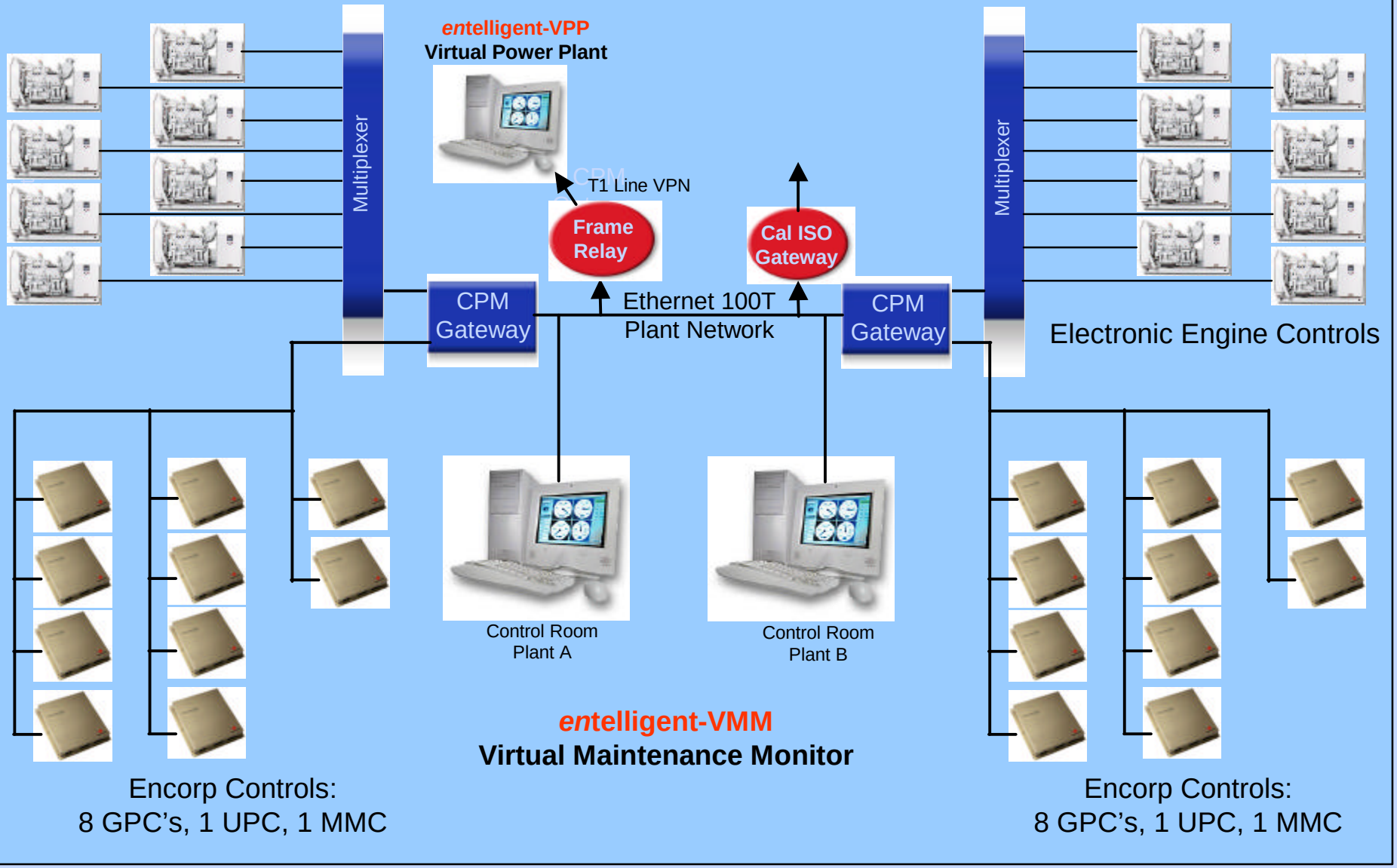
Case Study: Chowchilla II

Wholesale Distributed Generation

ISO Capacity and Energy Trading Systems



Chowchilla Communication Architecture



NREL/DOE Project Lessons Learned

- **Chowchilla Project Gives Valuable Insights On Future Distributed Power Needs**
  - **Continued focus on customer value proposition**
    - Cost savings
    - Expanded functionality
    - System-based solutions
  - **Importance of high-performance processing**
  - **Importance of communications, monitoring, diagnostics**
  - **Emphasis on ease of use and flexibility**
  - **Satisfying needs and concerns of electric power system operators**

Base Year Accomplishments

- **Program Meeting Expectations on Core Technology Development**
- **Parallel IEEE P1547 Standard Important**
  - **Defining functional requirements**
  - **Supporting standardization/rationalization on communications**
- **Functional Product Specifications Outlined for Advanced Controller**
  - **More powerful processor and enhanced controller architecture**

Base Year Accomplishments

- **New Controller Provides Several Advances**
  - **Up to twenty fold improvement in processing speed**
  - **Reduced controller footprint/volume (40%)**
  - **Reduced manufacturing costs**
  - **Simplified strategy for wiring and terminal connections**
    - Reduced manufacturing and field installation costs
  - **Expanded set of controller functions & scalability**
  - **Expanded communications capability**
- **Developed anti-islanding control scheme**
- **Developed loss-of-synchronization control scheme**

Base Year Accomplishments

- **Field Testing Case Study – Chowchilla**
  - **Results from field application of GPC controller**
  - **Requirements of working with California ISO, overall system**
    - Communications requirements
    - Communications topology
    - Communication protocols
    - Monitoring points
    - Load management
- **Draft final report**
  - **Describes controller development and field test of interconnection hardware**

Next Steps

- Gain market feedback on new controller and switchgear design
- Review ongoing IEEE P1547 Developments
  - Key issue are areas that may impact the new controller design
  - Type testing
- Review Option Year 1 plans
  - Refine detailed program plan as needed
  - Begin Phase II focus on type testing and system-level enhancements

Summary

- **Significant Opportunity Exists For Further Improving Distributed Power Value Proposition**
- **Advanced Interconnection Controls and Switchgear a Critical Part of the Equation**
- **Developing Consensus IEEE Standards for Interconnection and Communications Vital**
- **This Collaborative Program Has Resulted In Significant Technical Advances**
  - **Improved controller performance, greater functionality, and reduced switchgear cost**
  - **Our thanks to DOE, the Office of Power Technologies, and NREL for their support**